Collaborative Research: the Physics of Thermal and Superfluid Turbulence [Part 1 of 3: turbulent convection]

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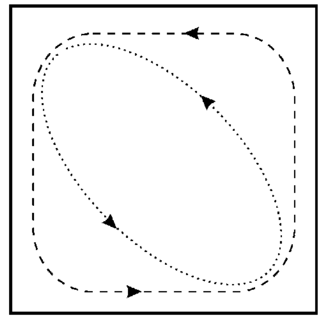
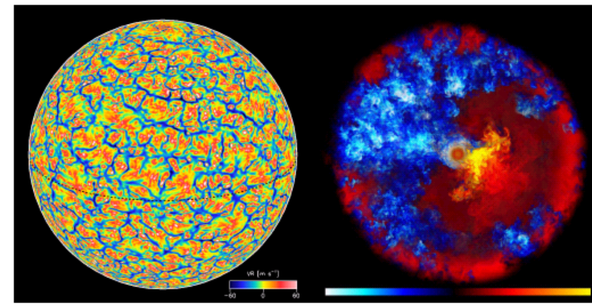
• Turbulent convection is ubiquitous in our Universe and plays a prominent role in stellar heat transport, atmospheric and oceanic dynamics, generation of the earth's magnetic field, continental plate tectonics, and many engineering applications.

•This complex, chaotic flow contains many small scale features, such as thermal plumes, which appear to self-organize into a coherent large scale circulation (see the leftmost figure, derived from experimental data).

•This same organization, seen in our recent measurements is also evident in simulations of the Sun (see figure on far right).





Left: Schematic of large scale circulation deduced from observations of the self-organized flow in turbulent convection experiments. (Full line: low Rayleigh numbers; dashed line: high Rayleigh numbers.) This circulation occasionally reverses itself completely, just as the polarity of the earth's magnetic field does.

Right two: Simulation plots of stellar convection (from NSF Report: "Computation as a Tool for Discovery in Physics") showing (left) fine scale granulation on the solar surface masking (right) a single self-organized circulation inside (color coding depicts temperature). Despite differences, the laboratory experiments appear to shed light on the turbulent motion inside stars.

Collaborative Research: the Physics of Thermal and Superfluid Turbulence (Part 2 of 3)

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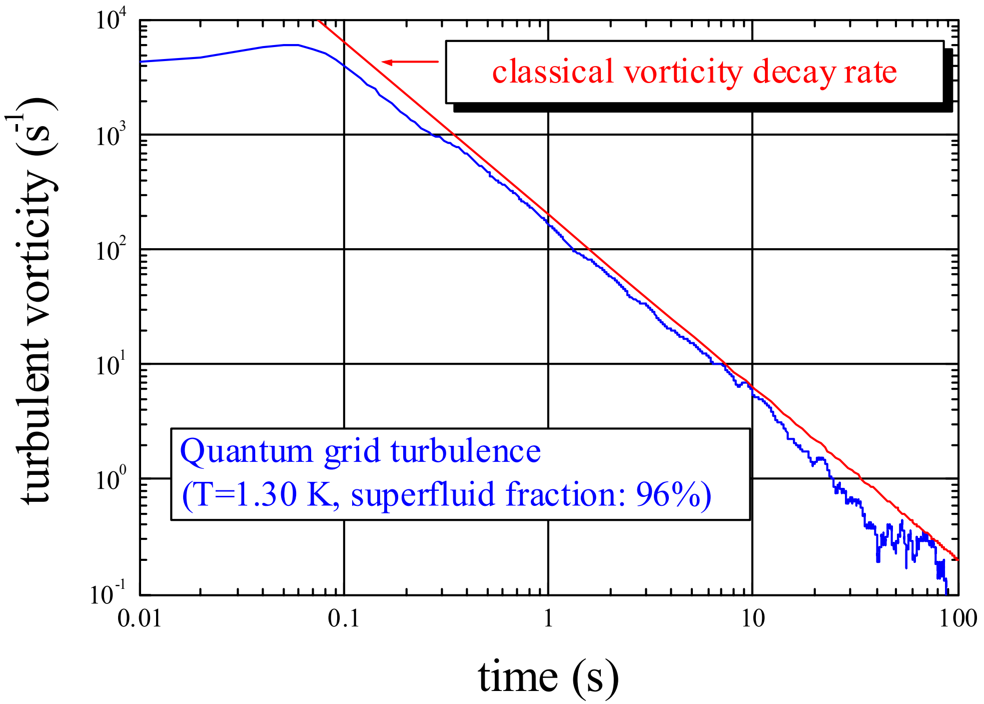
- Understanding of fluid turbulence is vitally important because it occurs in most fluid flows, and is a paradigm of strongly nonlinear problems.
- Our study of quantized turbulence (QT) reveals strong quantitative similarities with classical turbulence (see figure).
- It is likely that the understanding of quantum turbulence will ultimately provide a key to the elusive theoretical framework of classical turbulence.
- Understanding QT may be important also for the application of superfluid helium as a coolant for superconducting devices.



The decay of turbulent *quantized* vorticity generated by a moving grid in superfluid helium. The close correspondence with the classical decay rate is both unmistakable and astounding.

Collaborative Research: the Physics of Thermal and Superfluid Turbulence [Part 3 of 3: Education/Outreach]

K.R. Sreenivasan, R.J. Donnelly & J.J. Niemela, DMR-0202554

Education and outreach

• At the University of Oregon undergraduate Ian Sullivan has worked on experiments aimed at understanding vortex dynamics in classical fluids and is the recipient of a Goldwater fellowship.

• At the International Center for Theoretical Physics (ICTP) in Trieste, Italy, data obtained with the cryogenic thermal convection apparatus under this grant were analyzed by a Diploma student from Albania, Margarita Kuqali. Having completed her Diploma thesis (recognized as a Master's thesis at the University of Tirana), Margarita will continue her education towards a Ph.D. utilizing apparatus made possible through this grant.

• Also at ICTP, two new students from developing countries are working towards their Ph.D and Master's degrees respectively: Muhammed Raheel Mohyuddin from Pakistan, and Andrei Gorobets from Ukraine.